Circulation of the North Adriatic Sea during Winter 2002-03

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ABOUT THE PROGRAM

Objectives

We seek to improve understanding and modeling of shallow seas and shelves regarding

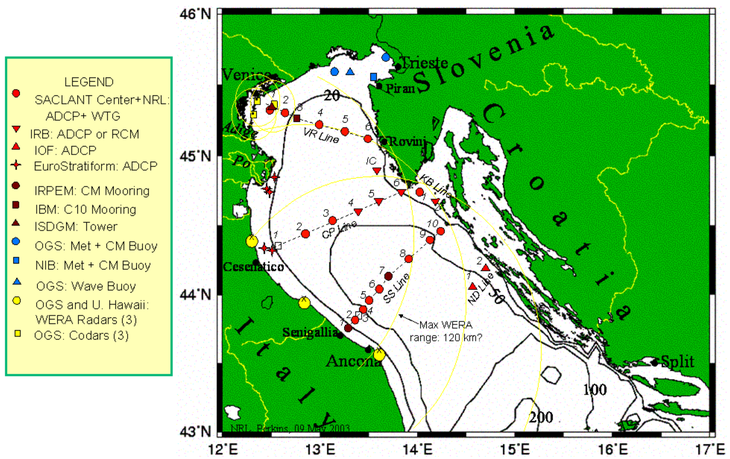
- Wind-driven response
- Density-driven response to surface fluxes
- Density-driven response to river inflow

The north Adriatic Sea is ideal for such a study. In winter, it repeatedly experiences very strong winds, most notably bora that blow from the northeast, channeled through mountain passes. These lead to wind-driven currents, full-depth convection, and density-driven flows. These responses are modified by freshwater input from the Po and other rivers.

Approach

We have worked closely with other institutions and programs in the region to create as comprehensive a data set as possible for the winter of 2002-03. The data will be assimilated into simple models to give a basin-wide oceanographic description, and used to evaluate more complex models such as the Navy's COAMPS-NCOM coupled air-sea model. Here we report on measurements from 14 ADCPs maintained by SACLANT Center and NRL during the winter.

Current Measurements, Winter 2002-03



Participants

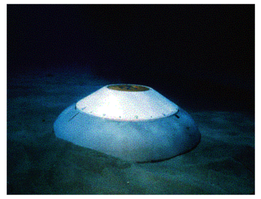
Naval Research Laboratory
SACLANT Center (SLC, La Spezia, Italy)
Istituto di Richerche sulla Pesca Marittima (IRPEM, Ancona, Italy)
Istituto per lo Studio della Dinamica delle Grandi Masse (ISDGM, Venice, Italy)
Istituto di Biologia del Mare (IBM, Venice, Italy)
Istituto Nazionale di Oceanografia e Geofisica Sperimentale (OGS, Trieste, Italy)
National Institute of Biology (NIB, Piran, Slovenia)
Rudjer Boskovic Institute (RBI, Rovinj and Zagreb, Croatia)
University of Zagreb (UZ, Zagreb, Croatia)
Institute of Oceanography and Fisheries (IOF, Split, Croatia)
Croatian Hydrographic Institute (CHI, Split, Croatia)
University of Washington (Seattle, WA) (ONR/PO - AMEX)
University of Miami (Miami, FL) (ONR/PO - AMEX)
University of Hawaii (Honolulu, HI) (ONR/PO - AMEX)
Dartmouth University (Hanover, NH) (ONR/PO - AMEX)
EuroSTRATAFORM Program (Several Institutions, ONR/G&G funding)
ADRICOSM Program (Several Institutions, European funding)

METHODOLOGY

Equipment

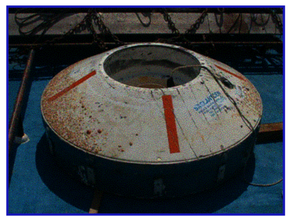
An array of 14 trawl-resistant bottom mounts (called Barnys after their barnacle-like shape) were deployed in the north Adriatic in late September 2002 and recovered in early May 2003. Each Barny housed an RDI Sentinel ADCP and most also included a Sea-Bird 026 Wave-Tide Gauge. All mooring operations were from the SACLANT Center vessel NRV Alliance in conjunction with intensive CTD surveys.

Barny TRBM on the bottom. The unit is 2.0 m in diameter, 0.5 m high and weighs some 750 kg in air. An outer ring of reinforced concrete, appearing blue here, provides ballast and impact protection. Photo courtesy of SACLANT Center



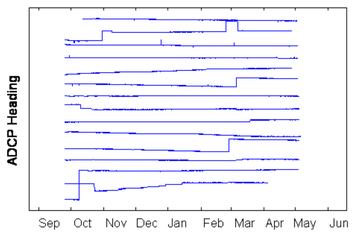
Hazards

Trawl resistance is critical. The north Adriatic is very heavily fished, even compared with other shallow regions. Conventional water-column moorings are at very high risk from trawlers. Particularly threatening for TRBMs is a bottom-towed, high-speed, harrow-and-net combination called "rapido".



Trawler damage to a test mooring during winter 2001-02 in 32 m depth near Senigallia, Italy. Parallel gouges have the spacing typical of rapido harrow teeth. Left panel: Barny pop-up recovery float with on-board ADCP. Right panel: main Barny housing less the ballast-bumper ring.

Time history of trawl impacts on the 14 Barnys. Each impact is revealed by an abrupt change in instrument heading, measured by the ADCP compass. Mean values of adjacent curves have been offset by 10°.



Mud is also a potential risk. In the extreme example at right, the Barny retrieved form from site SS2, the instrument housing is level full. It was recovered without incident.

Other problems encountered were:

- Biofouling - Confined to site VR2 and easily solved by more liberal application of anti-fouling paint
- Corrosion - A few near-failures from this source were traced to a batch of turnbuckles made from the wrong type of stainless steel.

Summary

Long-term measurements can be made under the severe conditions of the north Adriatic. From present experience, deployments of up to a year appear possible with an acceptable level of risk.

SOME EARLY RESULTS

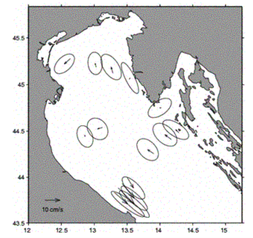
See also the poster of Book, et al.

Current Measurements

The preliminary figures below are drawn from the NRL and SLC ADCP data only. Additional data from the partners will complete the planned coverage. The integrated dataset will be used by the program partners in more comprehensive analyses.

Vertically and Temporally Averaged Currents

Mean vectors and standard deviation ellipses from all 7.5 months of data. As expected from earlier measurements and rotational dynamics, the inflow is northwestward along the Croatian coast and the outflow is southeastward along the Italian coast.

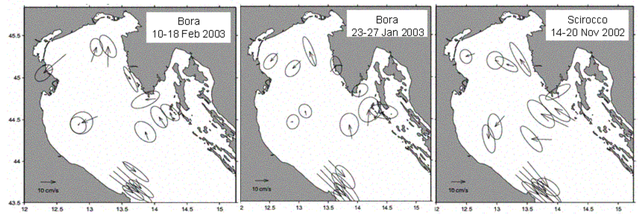


Response to Wind Events

Below, means and standard deviation ellipses are given for currents that have been averaged over depth and over the duration of the indicated wind event.

Bora refers to winds channeled southwestward through the Gulf of Trieste, Kvarner Bay, and other mountain passes further south

Scirocco refers to winds along the axis of the Adriatic, from SE to NW.



In the above figures, as well as in the long-term averages shown at top, the West Adriatic Current, is evident at bottom center. It is a very persistent feature, but strongly modulated by tidal-period currents. Elsewhere, evidence of the predicted bora-driven double-gyre circulation can be seen.

Modeling

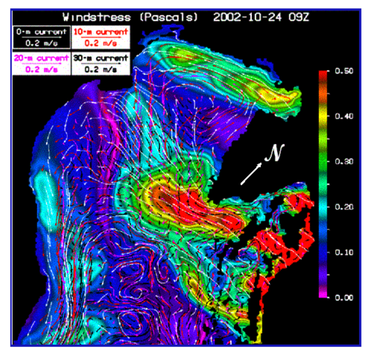
Model-assisted interpretation of this data and evaluation of the model simulations are being carried out in concert.

At right is one frame taken from an animation of modeled wind and currents during a bora. Note that the domain is rotated.

Color contours are wind stress from the COAMPS meteorological reanalysis, represented in this domain as a local nest at 4 km resolution. (courtesy of Jim Doyle, NRL). As is characteristic of bora, the strongest winds are directed southwestward and are strongly orographically channeled.

Currents are from NCOM with 1 km resolution and plotted at at four depth levels. The curved current vectors are simulated particle tracks for the 24 hours ending at the date/time of the image.

Note the agreement with the southernmost moorings shown above regarding the strength and width of the West Adriatic Current.



Conclusions

The current measurements shown here will be merged with those of the other program partners. Also to be incorporated in the final database are several CTD surveys made during the same time. Meteorological fields from COAMPS, validated at a few sites well removed from land, will serve to force ocean models, especially NCOM. We are optimistic that this combination of data and models will adequately describe the main features of the Adriatic circulation in winter.